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MACROECONOMIC CONSEQUENCES OF OUTSOURCING: AN ANALYSIS OF GROWTH, WELFARE, AND PRODUCT VARIETY**

BY

HENRI L.F. DE GROOT*

Summary

Outsourcing of non-core activities is nowadays a common business strategy. Declining transaction and transportation costs caused by the advent of Information and Communication Technology are a potentially important driving force behind this development. This paper provides a theoretical framework for analysing a firm's incentive to follow such a strategy of outsourcing and its consequences for macroeconomic variables like growth and product variety. We divide production activities into core and non-core activities. Non-core activities can be performed within the firm or can be mediated by the market. We derive conditions under which outsourcing occurs, and under which outsourcing is socially desirable. These conditions do not necessarily coincide. Outsourcing may hence be a profitable strategy for firms, while it is socially suboptimal. Crucial parameters in the model are the relative scale of core *versus* non-core activities, management costs, transaction costs and love for variety of consumers.

Key words: outsourcing, endogenous growth, product variety, transaction costs, welfare

1 INTRODUCTION

Outsourcing of activities to the service sector is nowadays a common business strategy. According to Abraham (1990) and Abraham and Taylor (1993), market mediated work arrangements associated with business service employment increased substantially over the period 1975-1990. For a longer period, Ten Raa and Wolff (2000) find a gradual increase in the share of total service inputs in gross output in both constant and current dollars in the period 1947-1996, with an acceleration during the 1980s. In current dollars, the ratio increased from 9.6% in 1947 to 18.4% in 1996, while in constant dollars it increased from 12% in 1947 to 18.4% in 1996. This evidence is suggestive for the importance of outsourcing. Part of the process of deindustrialization can be associated with this

* Department of Spatial Economics, Vrije Universiteit, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands; e-mail: hgroot@econ.vu.nl.

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development of 'splintering' (e.g., Bhagwati (1984) and Postner (1990)). Activities previously performed within a manufacturing firm (for example, accounting, maintenance, repair, janitorial and legal services) are currently performed in what is labelled the service sector.[1] These developments result in drastic changes of the *internal* organization of the firm and can thereby potentially influence both the firm's performance and the macroeconomic performance of an economy. This latter issue has received relatively little attention in the literature and will be the focus of this paper.

Abraham and Taylor (1993) distinguish three major factors that increase the likelihood of outsourcing, which they all find to be empirically relevant on the basis of establishment level data. First, outsourcing enables firms to save on wage and benefit payments. These savings can be achieved if activities can be contracted out to firms that offer less generous wages (see also Feenstra and Hanson (1995) for such an argument in an international context). Second, by outsourcing firms can transfer demand uncertainty to the outside contractor. This incentive can be relevant given the willingness of firms to smooth the work load of their regular work force. Required for profitability of outsourcing then is that the contractor supplies to firms that are (somewhat) unevenly hit by negative demand shocks. Finally, outsourcing may yield firms access to specialized skills and inputs that the firm cannot afford itself. This reason is especially relevant when economies of scale are involved in the supply of these production factors.

Along with the previously described benefits of outsourcing, there are also costs involved which are emphasised in the transaction cost literature. In this literature, a microanalytic approach is taken to the study of economic organization, with a focus on transaction costs and the efforts of organizations to economize on these (Williamson (1985), (1998)). From this perspective, outsourcing can be seen as a reorganizational effort aimed at reducing transaction costs, taking into account the comparative costs of planning, adapting, and monitoring task completion under alternative governance structures. The principal factor to which appeal is made is asset specificity. The argument runs as follows. With low asset specificity, the governance cost of mediation by the market is low relative to that of in-house provision. (As there is a low degree of bilateral dependency when asset

1 Francois and Reinert (1995) find some empirical evidence for this phenomenon, although they emphasize the importance of simultaneously considering changes in the structure of production for understanding the rise of the service sector. To the extent that 'splintering' is relevant, deindustrialization (defined as a decline in manufacturing employment) should not be seen as a *real* phenomenon but as resulting from measurement problems. In addition, this development puts popular statements that most new employment is generated by small service sector specialists in perspective, to the extent that this employment has simply been transferred from (large) goods-producing firms to the service sector (Postner (1990)). An interesting theoretical and empirical account of the consequences of outsourcing for the development of the sectoral composition of economies (in particular, the rise of service sector employment) and differential productivity growth between service and manufacturing productivity is given in Fixler and Siegel (1999).

specificity is limited, and the market restrains bureaucratic distortions more effectively, market mediation is relatively advantageous; see Williamson (1985) for an extensive justification of this argument.) Furthermore, the economies of scale to be gained by a single supplier operating in the market are potentially large. For these reasons, vertical integration is unlikely to be profitable with low asset specificity. However, as asset specificity increases, the bureaucratic costs of internal governance decrease relative to those of market mediation due to increased bilateral dependency, increased costs of control, and the need to sign detailed contracts that have limited adaptability. In addition, the benefits to be gained from economies of scale decrease as assets become more specific to the firm in question. Finally, high market power of the supplier of the specialized asset may result in a relatively high price for the asset. As a consequence, internal governance becomes more and more attractive when asset specificity increases. It ultimately becomes the preferred mode of governance, resulting in vertical integration (or 'insourcing' in the terminology of this paper).

The aim of this paper is twofold. First, we want to embed the previous informal arguments of the transaction cost literature in a formal dynamic general equilibrium model. Second, we want to consider the macroeconomic consequences of outsourcing for economic growth, product variety, and economic welfare. By means of illustration, the model will be used to analyse the potential macroeconomic consequences of the advent of Information and Communication Technology (ICT). For this aim, we define outsourcing as vertical disintegration of production (i.e., buying indirect inputs on the market instead of producing them internally). The primary motive for outsourcing will be that it can give rise to the exploitation of economies of scale present in the production of the indirect inputs. In empirical studies on outsourcing, cost savings resulting from the exploitation of economies of scale or access to specialized inputs feature prominently as one of the primary motivations for firms to engage in outsourcing (e.g., Abraham and Taylor (1993)). The model that we develop allows us to analyse under what conditions outsourcing is a profitable strategy. Having established if, for what reason, and under what conditions a firm engages in outsourcing, we analyse the macroeconomic consequences for the growth rate, product variety, and economic welfare. We show that private profitability and social desirability of outsourcing do not in general coincide; situations can arise in which outsourcing occurs in a market economy at the expense of consumers' welfare.

This paper proceeds as follows. In section 2, we present the model and its solution. The welfare characteristics of the model are discussed in section 3. In section 4, we illustrate the working of the model by studying the macroeconomic consequences of declining transaction costs. This illustration is interesting in the light of the advent of ICT. We also derive under what conditions the market equilibrium of the model is socially optimal. Section 5 concludes.

2 THE MODEL

The basic idea of the model that we develop is simple. We have a closed economy with one final goods sector in which a variety of differentiated consumer goods are produced. There is only one factor of production – labour – that is homogeneous and supplied inelastically. Consumers have a love for variety of consumption goods. Each unique variety of the consumption good is produced by a single producer. Producers compete monopolistically à la Chamberlin and in equilibrium they earn zero (excess) profits due to free entry and exit of firms. The costs of producing the final consumption good consist of four parts, namely (i) direct wage costs resulting from the primary or core activities of the firm, (ii) indirect costs resulting from the support or non-core activities of the firm (such as accounting, cleaning, janitorial, maintenance and repair services), (iii) management costs that have to be incurred before the firm is able to produce and (iv) the costs associated with the engagement in R&D activities. The support activities that form an input in the production process can be acquired in two ways. Firms can produce them internally by employing labour or they can engage in outsourcing, that is buying the good on the market. The decision whether or not to engage in outsourcing and the macroeconomic consequences of this decision are at the heart of the analysis in this paper. The management costs depend on the mode of governance that firms adopt. That is, whether firms engage in outsourcing or whether they stick to the internal provision of the good or service in question. This assumption is in line with the insights from the transaction cost literature as it was discussed in the introduction. We return to the modelling of management costs in section 4. The research that is performed by the firms results in increased total factor productivity (TFP) and forms the 'engine of growth' in the model. In the remainder of this section, we will discuss the model more formally. Section 2.1 describes consumer behaviour, section 2.2 discusses producer behaviour, and section 2.3 presents the equilibrium solution of the model. We will compare the growth rates, firm size, and product variety in the two respective regimes of internal provision and outsourcing of the support activity.

2.1 *Consumer behaviour*

Consumers maximize their intertemporal utility. They do so in two steps. In the first step, the decision is made how much of the earnings are allocated to savings and how much to consumption. In the second step, the income allocated to consumption is divided over the varieties of the consumption good that are available. More formally, in the first step a representative infinitely lived consumer maxi-

mizes her intertemporal utility subject to a dynamic budget constraint:

$$max\ U = \int_0^{\infty} \frac{C_t^{1-\rho}}{1-\rho} e^{-\theta t} dt \quad \text{s.t.} \quad \dot{A}_t = r_t A_t + w_t L_t + \pi_Y - C_t P_{Ct}\,, \qquad (1)$$

where C is a consumption index, $1/\rho$ is the intertemporal elasticity of substitution (which is assumed to be smaller than one), θ is the subjective discount rate, A is wealth, r is the interest rate, w is the wage rate, π_Y are profits made in the sector that potentially supplies the producers of the consumption goods with their support activities,[2] and P_C is the price index corresponding to the composite of consumption goods. Standard dynamic optimization yields the familiar Ramsey rule (a dot above a variable represents a derivative with respect to time, so $\dot{C}_t \equiv dC/dt$):

$$\frac{\dot{C}_t}{C_t} = \frac{r_t - \dot{P}_{Ct}/P_{Ct} - \theta}{\rho}\,, \qquad (2)$$

according to which consumers accept a steeper consumption profile the larger the difference between the real interest rate $(r - \dot{P}_C/P_C)$ and the subjective discount rate, and/or the larger the intertemporal elasticity of substitution.

The composite good C is composed of varieties of consumption goods (indexed $i = 1, ..., N$ with N being the number of varieties available on the market). We assume that consumers have a love for variety. In the second step of their optimization, consumers maximize this consumption index subject to a static budget constraint:

$$C = N^{\sigma}\left[\frac{1}{N}\sum_{i=1}^{N} c_i^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}} \quad \text{s.t.} \quad \sum_{i=1}^{N} c_i p_{ci} \leq C P_C\,, \qquad (3)$$

where c_i is the consumed quantity of the consumption good of variety i and ε is the elasticity of substitution between any pair of consumption goods. Consumption goods of different types are imperfect substitutes ($\varepsilon > 1$). The parameter σ captures the love for variety. This is – contrary to Dixit and Stiglitz (1977) – explicitly distinguished from the elasticity of substitution between any pair of consumption goods. (In the case considered by Dixit and Stiglitz, the parameter capturing love for variety equals $\varepsilon/[\varepsilon - 1]$). We assume σ to be larger than one. The

2 Profits in the consumption goods sector are 'by definition' equal to zero because of the free entry and exit assumption, so we may omit these profits in the dynamic budget constraint. In the equilibrium in which the support activities are performed internally, the sector providing these activities is not operating and hence $\pi_Y = 0$.

consumption index can then, under symmetry, be written as $C = N^{\sigma-1}(Nc)$. Under the assumption of $\sigma > 1$, consumers prefer of two equally sized bundles the one with the greatest variety (N). As we show in sections 3 and 4, the distinction between the elasticity of substitution and the love for variety is crucial for the welfare results that we obtain (see also Benassy (1996), Broer and Heijdra (1996) and de Groot and Nahuis (1997)). Optimization yields a standard downward-sloping demand curve for consumption goods:

$$c_i = \left(\frac{p_{ci} \sum_{i=1}^{N} c_i^{\frac{\varepsilon-1}{\varepsilon}}}{C} \right)^{-\varepsilon} . \tag{4}$$

2.2 *Producer behaviour*

Each (unique) variety of the consumption good is produced by a single firm. The N firms that are operating in the economy aim at maximizing their present discounted value by selling the unique brand of the consumption good that they produce. The production process requires two (direct) inputs, namely direct labour (L_{ci}) and support activities (y_i). Total factor productivity (TFP) equals h_i. For simplicity, we assume that production takes place with a Leontief production technology (there are no substitution possibilities between the inputs). We think that this assumption of no (or at least limited) substitution possibilities between core and support activities matches reality quite well. The production function can then be written as[3]:

$$c_i = h_i \min \left[L_{ci}, \frac{y_i}{a} \right] . \tag{5}$$

3 A generalization of the model allows for a division of the support activity into M activities (indexed $m = 1, ..., M$), each with its own characteristics. An example of a generalization would be the following production function:

$$c_i = h_i \min \left[L_{ci}, \left(\frac{y_{i,m} - f_m}{a_m} \right)^{\frac{1}{\gamma_m}} \right] .$$

In this representation, a fixed amount of the support activity f_m is required before the firm is able to produce and we allow for the potential of decreasing or increasing requirements with scale (γ_m smaller or larger than one, respectively). In the model in this paper, we use a specification characterized by $\gamma_m = 1$, $M = 1$, and $f_m = 0$. This generalization would seriously complicate the analysis. However, it is easily imagined that an equilibrium results in which a fraction of the support activities is outsourced, while another fraction is produced internally. Additionally, in such a setting the management costs could be modelled as a (declining) function of the fraction of support activities that has been outsourced (see Dluhosch (1997) for a similar kind of modelling).

So the unit labour requirement equals $1/h_i$ and the unit support activity requirement equals a/h_i. Hence, the input ratio between (direct) labour and support activities is equal to $1/a$.

Inspired by Smulders and Van de Klundert (1995), we assume that TFP has important firm-specific or tacit elements. Firms can increase productivity by engaging in R&D. The productivity of R&D labour increases with own knowledge accumulated in the past:

$$\dot{h}_i = \xi h_i L_{ri}\,, \tag{6}$$

where L_r is labour employed in R&D and ξ is the productivity parameter of doing research. We deliberately simplify the analysis by assuming that knowledge is completely internal to the firm. There are thus no externalities resulting from interfirm knowledge spillovers. This simplification allows us to focus on the crucial externalities in the context of the decision to engage in outsourcing (see sections 3 and 4) without having to bother about the externality created by spillovers of knowledge between firms. Since the reproducible factor (h) in the model can be reproduced with constant returns to scale with respect to itself (the core property), the model is characterized by endogenous growth.

Finally, each producer has to employ a fixed amount of management labour (L_m) in each period before being able to produce. The cost of management is a traditional fixed cost and will depend on the adopted mode of governance (see section 4).

We can now turn to the optimization problem of the firm. This problem is split in two steps. In the first step, the firm decides whether or not to engage in outsourcing. For simplicity and without loss of generality, we assume that in taking this decision firms only consider and compare the unit costs of the support activity in case of internal provision and outsourcing, respectively. So in deciding which mode of governance to adopt, firms do not take into account the consequence of this choice for the management cost.[4] As the unit cost of the support activity in the regime in which firms engage in outsourcing can only be determined after solving the complete model, we can only turn to the outsourcing decision after we have established the general equilibrium solution of the model. This solution is presented in the next section. But before turning to this solution, we need to analyse the second step of the firm's optimization problem. After the firm has decided about its mode of governance (which is indexed by j, equalling I when the firm provides the support activity internally and O when it engages in

4 This assumption is relaxed in De Groot (1998) where the model is solved in case producers of the consumption goods do take into account the consequences of their decision to engage in outsourcing for the management cost. The basic results we derive in this paper are not altered by relaxing this assumption, but the analysis becomes more complicated.

outsourcing), it maximizes its present discounted value:

$$\max_{L_{ci}^j,\, L_{ri}^j} \int_0^\infty [c_i^j\, p_{ci}^j - (L_{ci}^j + L_{ri}^j + L_m^j)\, w - y_i^j\, p_Y^j] e^{-rt}\, \mathrm{d}t\,, \tag{7}$$

subject to equations (4), (5), and (6). In this specification, p_Y is the cost of the support activity (which is produced internally or bought on the market). Standard dynamic optimization of the current-value Hamiltonian yields three first-order conditions. The first says that firms put a mark-up of $\varepsilon/(\varepsilon - 1)$ on unit costs ($[w+ap_Y]/h$):

$$\frac{\partial H}{\partial c_i^j} = p_{ci}^j \left(1 - \frac{1}{\varepsilon}\right) - \frac{w + ap_Y^j}{h_i^j} = 0 \;\Leftrightarrow\; p_{ci}^j = \frac{\varepsilon}{\varepsilon - 1}\, \frac{w + ap_Y^j}{h_i^j}\,. \tag{8}$$

The second indicates that firms change the number of R&D workers until the marginal benefit of the last worker ($\xi p_h h$) equals its marginal cost (w), where p_h is the shadow price corresponding to knowledge:

$$\frac{\partial H}{\partial L_{ri}^j} = p_{hi}^j \xi h_i^j - w = 0 \;\Leftrightarrow\; p_m^j \xi h_i^j = w\,. \tag{9}$$

Finally, there is a no-arbitrage condition stating that investing an amount p_h in the financial market at rate r should yield the same return as investing in knowledge capital, which yields a capital gain, an increase in production, and an increase in the knowledge base:

$$\frac{\partial H}{\delta h_i^j} = p_{ci}^j L_{ci}^j \left(1 - \frac{1}{\varepsilon}\right) + p_{hi}^j \xi L_{ri}^j = r^j p_{hi}^j - \dot{p}_{hi}^j \;\Leftrightarrow$$

$$r = \frac{\dot{p}_{hi}^j}{p_{hi}^j} + L_{ci}^j \frac{p_{ci}^j}{p_{hi}^j}\, \frac{\varepsilon - 1}{\varepsilon} + \xi L_{ri}^j\,. \tag{10}$$

In the remainder, we omit the governance index j where it leads to no confusion.

2.3 *Solution of the model*

In the previous sections we discussed consumer behaviour and producer behaviour that applies after producers have decided whether or not to engage in outsourcing. This decision depends on the characteristics of the general equilibrium solution of the model that we discuss in this section. First, we describe in section

2.3.1 the equilibrium that results if firms would decide to produce the support activity internally. In section 2.3.2, the equilibrium with outsourcing is described. Section 2.3.3 compares both equilibria and discusses which equilibrium prevails in the market economy.

2.3.1 Equilibrium with internal provision of the support activities

In the equilibrium with internal provision of the support activity (y_i) this activity is produced with labour (L_{yi}) according to a constant returns to scale technology:

$$y_i = L_{yi}\,. \tag{11}$$

The cost of one unit of the support activity thus equals w. The model is closed by imposing a zero-profit condition, stating that entry or exit occurs until profits in the consumption goods sector equal zero:

$$c_i\, p_{ci} = (L_{ci} + L_{yi} + L_{ri} + L_m^I)\, w\,, \tag{12}$$

and by imposing a labour market constraint:

$$L = \sum_{i=1}^{N} (L_{ci} + L_{yi} + L_{ri} + L_m^I)\,, \tag{13}$$

where L is exogenous labour supply. Assuming symmetry between firms, we can drop firm indices and solve for the steady state of the model, taking the wage rate as numeraire ($w = 1$). This yields the steady-state growth rate (see Appendix A):

$$g^I \equiv \frac{\dot{h}^I}{h^I} = \frac{\xi(\varepsilon - 1)}{\rho - \varepsilon}\left[L_m^I - \frac{\theta}{\xi(\varepsilon - 1)}\right], \tag{14}$$

and the equilibrium number of firms and the number of production workers (see Appendix A)[5]:

$$N^I = \frac{L\xi(\rho - \varepsilon)}{[\xi(\rho - 1)\, L_m^I - \theta]\, \varepsilon} \quad \text{and} \quad L_c^I = \frac{(\varepsilon - 1)[\xi(\rho - 1)L_m^I - \theta]}{\xi(\rho - \varepsilon)\,(1 + a)}\,. \tag{15}$$

An important notion that will recur in the analysis is that the growth rate depends positively on the management costs, and that the equilibrium number of firms depends negatively on these management costs. As management costs in-

5 Stability of the equilibrium with a positive growth rate requires the following restriction on the parameters: $(\rho - 1) > (\varepsilon - 1) > \theta/\xi L_m^I$.

crease, there is less room for firms with non-negative profits (the equilibrium number of firms declines). As a consequence, each remaining individual firm becomes larger in size and its market share increases. This increased market share increases the incentive for firms to engage in R&D, as each firm can now spread its (quasi) fixed R&D cost over a larger output. The growth rate will consequently increase, reflecting the Schumpeterian character of the model.[6] Another characteristic of the equilibrium is that the macroeconomic production of non-core activities ($N^I a L_c^I = (\varepsilon - 1)aL/[\varepsilon(1 + a)]$) is independent of the management cost. An increase in the management costs leads to an increase in firm size and to an equi-proportionate decrease in the number of firms. The macroeconomic demand for non-core activities is positively related to the mark-up. The explanation for this is that a low mark-up leaves limited room for firms with non-negative profits. The macroeconomic employment of management labour ($N^I L_m^I$) consequently goes down, leaving more room for productive activities.

2.3.2 Equilibrium with outsourcing of the support activities

In the equilibrium with outsourcing, a monopolist with access to a superior fixed-cost technology can produce the support activities according to:

$$Y = \delta(L_Y - F)\,, \tag{16}$$

where Y is production of non-core activities, L_Y is labour employed by the monopolist, δ is the marginal productivity of labour, and F is a fixed cost expressed in units of labour. In a symmetric equilibrium, the output of the monopolist (Y) equals the demand from the producers of the consumption goods (Ny_i). The superiority of the production technology is reflected in the assumption we make that $\delta > 1$. The fixed cost can be seen in part as a cost that has to be incurred in each period by the monopolist to establish and maintain a relationship with its customers (the users of the non-core activities)[7] and in part as the cost of acquiring and using the superior technology. Crucial is that the production technology of the monopolist is characterized by increasing returns to scale. As discussed in the introduction, exploiting economies of scale is an important motivation for outsourcing.

For outsourcing to take place, it has to be beneficial for both the monopolist and the producers of consumption goods. This means that the price of the non-

6 Clearly, there are other insights in the literature on the effects of competition, possibly even caused by increased outsourcing, that predict a positive relationship between competition and growth and which are also associated with the work of Schumpeter. A discussion on this debate is beyond the scope of this paper. We refer to, for example, Agion and Howitt (1998) for a discussion on this issue.

7 See, for example, Kelley (1997) for a model in which the monopolist can explicitly invest in establishing a relation with customers and thereby enlarge the market it can supply. Similar considerations could be built in our model, but would significantly complicate the analysis without adding to the basic insights.

core activity should be sufficiently low in order to trigger the producer of the consumption goods to shift from internal production to outsourcing, while it should be sufficiently high to enable the monopolist to earn a profit. These conditions imply that the monopolist will engage in limit pricing,[8] charging a price for the support activity (p_Y) that will be equal to w (the unit cost of a support activity if produced internally). Pricing by the monopolist of the non-core activity slightly below this unit cost makes it profitable for the producer of the consumption good to engage in outsourcing, and hence it will take the decision to do so.[9] So also in the regime with outsourcing, $p_Y = w$. As a result, the cost structure in this regime is exactly the same as in the regime with internal provision. The model is again closed by imposing a zero-profit condition, stating that entry or exit occurs as long as profits are unequal to zero:

$$c_i p_{ci} = (L_{ci} + L_{ri} + L_m^O) w + y_i p_Y , \tag{17}$$

and by imposing a labour-market constraint:

$$L = \sum_{i=1}^{N} (L_{ci} + L_{ri} + L_m^O) + L_Y . \tag{18}$$

The steady-state growth rate can now be obtained as (see Appendix A)[10]:

$$g^O = \frac{\xi(\varepsilon - 1)}{\rho - \varepsilon} \left[L_m^O - \frac{\theta}{\xi(\varepsilon - 1)} \right] . \tag{19}$$

The equilibrium number of firms and the equilibrium number of production workers per firm equals (see Appendix A):

$$N^O = \frac{(L - F)\,\delta\xi(\rho - \varepsilon)\,(1 + ap_Y)}{[a(\varepsilon - 1 + \delta p_Y) + \delta\varepsilon]\,[\xi(\rho - 1) L_m^O - \theta]} \quad \text{and}$$

$$L_c^O = \frac{(\varepsilon - 1)[\xi(\rho - 1) L_m^O - \theta]}{\xi(\rho - \varepsilon)\,(1 + ap_Y)} . \tag{20}$$

8 We formally show in Appendix A that it is optimal for the monopolist to charge as high a price as possible, and thus to engage in limit pricing.

9 Of course, there are more considerations to this decision not taken into account in this model for reasons of simplicity, like considerations of increased uncertainty or reduced quality of the non-core activities once a firm engages in outsourcing. Such extensions are interesting but beyond the scope of this paper.

10 Stability of the equilibrium with a positive growth rate requires the following restriction on the parameters: $(\rho - 1) > (\varepsilon - 1) > \theta / \xi L_m^O$.

Again, the macroeconomic demand for non-core activities ($N^O a L_C^O$) is not affected by the management costs for the same reason as discussed in section 2.3.1. The equilibrium number of firms now not only crucially depends on management costs, but also on the superiority of the technology that the monopolist employs to produce the support activity. The higher the productivity of the technology (δ), the lower the fixed cost (F), and the higher the intensity with which non-core activities are used (a), the more firms can be sustained in equilibrium. As the fixed cost technology improves, less labour is required to produce support activities leaving more labour for production of consumption goods resulting in larger variety.

2.3.3 Comparison of the two regimes and equilibrium selection

In this section, we compare the macroeconomic characteristics of the two respective equilibria in terms of product variety, firm size, the production volume and the growth rate. Next, we derive which equilibrium will prevail in the market economy. Growth rates differ to the extent that there are differences in the management costs (compare equations (14) and (19)). If these costs are higher in the regime with outsourcing, the room for firms with non-negative profits decreases, the market shares of remaining firms increase, the incentive to engage in R&D increases, and hence the growth rate will be higher (and the other way around).

Comparing product variety (as measured by N; see equations (15) and (20)) in the two equilibria boils down to:

$$N^I > N^O \text{ iff}$$

$$\frac{L}{[\xi(\rho-1)L_m^I - \theta]} > \frac{(L-F)(1+a)\delta\varepsilon}{[a(\varepsilon-1+\delta)+\delta\varepsilon][\xi(\rho-1)L_m^O - \theta]}. \tag{21}$$

So the relative number of firms in the two regimes depends essentially on the relative amount of management labour in the two equilibria and the superiority of the fixed cost technology of the monopolist.[11] The more management labour is needed in the regime with internal provision relative to the regime with outsourcing, the lower will be the relative number of firms in the regime with internal provision. The more superior the fixed cost technology is, the higher the relative number of firms in the regime with outsourcing.

Outsourcing will be a *feasible* strategy if profits for the monopolist supplying the support activities are positive at the limit price ($p_Y = w$). Using equation (20) this condition boils down to:

11 Subtracting the solution for the number of firms under outsourcing (equation (20)) from the solution for the number of firms under in-house provision (equation (15)), and taking derivatives, it can be verified that $d(N^I - N^O)/dL_m^I < 0$, $d(N^I - N^O)/dL_m^O > 0$, $d(N^I - N^O)/dF > 0$, $d(N^I - N^O)/da < 0$, and $d(N^I - N^O)/d\delta < 0$.

$$\pi_Y = p_Y N^O y^O - wL_Y = w\left[N^O a L_c^O\left(\frac{\delta-1}{\delta}\right) - F\right] \geq 0 \;\Leftrightarrow$$
$$La(\varepsilon-1)(\delta-1) \geq F\varepsilon\delta(1+a)\,. \tag{22}$$

Producing $N^O y^O$ internally would require $N^O a L_c^O$ units of labour. Outsourcing is in other words feasible (and will thus occur) if the labour requirement by the monopolist (L_Y) is smaller than the amount of labour required for the same production volume under in-house provision. Note that the management requirement does not enter in the condition for outsourcing to be profitable (see equation (22)). The reason is that an increase in the management cost leads to an equiproportionate decrease in the firm size and thus leaves the macroeconomic demand for non-core activities unaffected. Alternatively, we can show that the monopolist is willing to supply the non-core activity (i.e., $\pi_Y > 0$) in the specific case in which the macroeconomic demand for non-core activities is larger in the regime with outsourcing than in the regime with internal provision, which boils down to[12]:

$$N^O = \frac{N^I a L_c^I}{a L_c^O} = \frac{\xi L(\rho-\varepsilon)}{\varepsilon[\xi(\rho-1)L_m^O - \theta]}\,. \tag{23}$$

We can interpret this condition as the minimum number of firms that has to be sustained for outsourcing to be a profitable strategy for the monopolist (given the limit price he can maximally charge). Results with respect to the likelihood of the occurrence of outsourcing are summarized in proposition 1.

> *Proposition 1. Outsourcing is more likely to occur the larger the scale of the economy* (L)*, the lower the fixed cost of the superior technology* (F)*, the higher the productivity of the superior technology* (δ)*, the greater the demand for the support activity* (a)*, and the larger the elasticity of substitution* (ε)*; see equation* (*22*).

So outsourcing will occur if the fixed cost technology is sufficiently superior, if the scale of the economy is large so that the fixed cost of the superior technology can easily be spread over a large output (the degree of specialization is limited by the size of the market), and if consumption goods are close substitutes. This last result can be understood, as close substitutability between consumption goods implies strong competition between producers of consumption goods and a relatively small number of firms. There will consequently be much labour left for productive purposes as the amount of labour required for management activities

12 Using the solutions for N^j and L_c^j, we can derive a condition for which macroeconomic demand is equal in the two regimes. This condition boils down to $La(\varepsilon-1)(\delta-1) = F\varepsilon\delta(1+a)$. This condition is equal to the condition $\pi_Y = 0$.

(NL_m) is relatively small. The demand for support activities will consequently be relatively large, and the profitability for the monopolist with access to the superior technology increases. Competition thus fosters outsourcing.[13]

3 OUTSOURCING AND WELFARE: GROWTH *VERSUS* PRODUCT VARIETY

Having established the two equilibria of the model as well as which equilibrium will prevail in the market economy, we will now turn to the welfare characteristics of the model by deriving and comparing welfare in the two respective regimes. In order to make a welfare evaluation of the social desirability of outsourcing, we need to compare the present discounted utility of the representative consumer in the two equilibria of the model. We recall from section 2.1 that the present discounted utility equals

$$U_0 = \int_0^\infty \frac{C_t^{1-\rho}}{1-\rho} e^{-\theta t}\, \mathrm{d}t\,. \tag{24}$$

Substituting equation (5) into equation (3) and using the fact that the allocation of labour and the growth rate are constant over time (due to the absence of transitional dynamics), we derive:

$$C = N^\sigma c_i = N^\sigma h_0 e^{gt} L_c\,, \tag{25}$$

where h_0 is the initial productivity level at time $t = 0$ (which subsequently grows at a constant rate g). We can thus derive the present discounted value of utility as:

$$U_0 = \int_0^\infty \frac{[N^\sigma h_0 L_c]^{1-\rho}}{1-\rho} e^{[(1-\rho)g-\theta]t}\, \mathrm{d}t\,. \tag{26}$$

Integrating this expression finally yields:

$$U_0 = \frac{-1}{(\rho-1)\,[g(\rho-1)+\theta]\,[N^{\sigma-1} h_0 (NL_c)]^{\rho-1}}\,. \tag{27}$$

13 A similar result is derived in a trade model by Dluhosch (1997). Trade is argued to enhance competition and thereby increase the scale of firms and increase the incentive to save on production costs. This is shown to result in an increased slicing of the value chain and an increase in outsourcing.

The present discounted utility of consumers is essentially determined by three factors. First, the growth rate has a positive effect on utility. Second, product variety positively affects utility (captured by the term $N^{\sigma-1}$), which is due to the variety effect in consumer preferences ($\sigma > 1$). Finally, utility is positively affected by the produced volume of consumption goods (basically captured by NL_c). Given our previous discussion of the characteristics of the model, it will be evident that there are two trade-offs involved here. Research labour goes at the expense of production labour, while product variety goes at the expense of both growth and production volume.

To compare welfare under the two regimes, we look at the difference in utility between the two regimes[14]:

$$\text{sgn.}\,(U^O - U^I) =$$

$$\text{sgn.}\left(\left[\frac{\xi(\rho-1)L_m^O - \theta}{\xi(\rho-1)L_m^I - \theta}\right]^{\frac{\rho}{\sigma(\rho-1)}-1} - \left[\frac{L[a(\varepsilon-1+\delta)+\delta\varepsilon]}{(L-F)(1+a)\delta\varepsilon}\right]\right). \qquad (28)$$

From this equation, we can derive proposition 2.

> *Proposition 2. Outsourcing is more likely to be socially beneficial the larger the scale of the economy* (L)*, the lower the fixed cost of the superior technology* (F)*, the higher the productivity of the superior technology* (δ)*, the greater the demand for the support activity* (a)*, and the larger the elasticity of substitution* (ε)*. Furthermore, outsourcing is more likely to be socially desirable the higher* (*lower*) *the relative management cost* (L_m^O/L_m^I) *provided that* $\sigma < (>)\rho/(\rho-1)$*; see comparative statics of equation* (*32*).

So the desirability of outsourcing increases with the superiority of the fixed-cost technology (captured by parameters δ, a, L, and F). Also, a larger elasticity of substitution increases the desirability of outsourcing, as close substitutability between consumption goods implies strong competition and a relatively small number of firms. There will consequently be much labour left for productive purposes, as the amount of labour required for management activities (NL_m) is relatively small. The demand for support activities will consequently be relatively high, increasing the desirability of exploiting the economies of scale to be gained

14 Using equation (27), we derive

$$\text{sgn.}\,(U^O - U^I) = \text{sgn.}\left(\frac{-1}{[g^O(\rho-1)+\theta][(N^O)^\sigma L_c^O]^{\rho-1}} + \frac{1}{[g^I(\rho-1)+\theta][(N^I)^\sigma L_c^I]^{\rho-1}}\right).$$

Substituting the expressions for g^j, N^j, and L_c^j from equations (14), (15), (19), and (20) and rewriting yields equation (28).

by using the superior technology. The effect of the (relative) management costs in the respective modes of governance (L_m^O/L_m^I) on the desirability of outsourcing depends on the strength of the love for variety (σ) relative to the intertemporal elasticity of substitution ($1/\rho$). To understand this, we have to keep in mind that our model is characterized by a trade off between growth and product variety. The economy is characterized by either a few large firms with large market shares and huge incentives to engage in R&D, or by many small firms with small market shares and limited incentives to perform R&D activities. We have seen in section 2 that high management costs result in little product variety, large market shares for firms, and an accordingly large incentive to engage in R&D. Now suppose that the regime switch from internal provision to outsourcing is accompanied by a decrease in management costs. Outsourcing will then be accompanied by an increase in product variety and a decrease in the growth rate. The lower the relative management cost (L_m^O/L_m^I), the stronger this effect will be. The desirability of outsourcing will hence be positively affected by a decrease in relative management costs if the love for variety is strong relative to the intertemporal elasticity of substitution. If the love for variety is weak relative to the intertemporal elasticity of substitution, a decrease in the relative management cost will decrease the likelihood that utility in the regime with outsourcing is larger than in the regime with internal provision. In the intermediate case, where $\sigma = \rho/(\rho - 1)$, the growth and variety effects on utility exactly cancel each other out. The increased likelihood that outsourcing is socially desirable due to increased growth is exactly offset by its decreased likelihood due to reduced variety. Relative utility is hence not affected by relative management costs in this specific case.[15]

4 OUTSOURCING AND THE ADVENT OF ICT

The advent of ICT is generally argued to be an important driving force behind the increased tendency to outsource non-core activities. Audretsch (1995) argues the introduction of computers to be an important factor for explaining the massive downsizing of companies in the early 1990s in both Germany and the USA. First, it reduced the amount of labour needed to produce a certain amount of goods. Second, it also reduced firm size because '...information technology allows for closer relations with suppliers and customers, thus making it possible for firms to narrow their focus and spin-off previously integrated activities. Thus, while the trend towards downsizing was initially triggered by the need to reduce costs, it also reflects the administrative impact of information and communication technologies. Increased use of technologies, such as electronic mail, voice mail,

15 Mathematically, these results follow from considering the power in equation (28). If $\sigma > \rho/(\rho - 1)$, this power is negative and hence $d(U^O - U^I)/d(L_m^O/L_m^I) < 0$. If $\sigma = \rho/(\rho - 1)$, this power is equal to zero and hence $d(U^O - U^I)/d(L_m^O/L_m^I) = 0$.

and shared databases, has, over time, reduced the need for traditional middle management, whose role was to supervise others and to collect, analyse, evaluate, and transmit information up, down, and across the organizational hierarchy.' (p.27).

In a somewhat broader context, Freeman and Soete (1994) discuss the advent of information and communication technology, which they argue to be a new techno-economic paradigm. The pervasiveness of this new paradigm is argued to extend beyond just a few products or industries, and to affect every industry, every service, their interrelationships, and indeed the whole way of life of industrial societies. One of their arguments is that: 'Because of rapid, easy access to information at all levels both vertically and horizontally, intermediate layers of management were often no longer necessary. The need for rapid response and greater decentralisation of responsibility within the new production and management systems also intensified this pressure towards 'downsizing' by reducing the number of middle managers. ... A similar trend was clearly evident in Europe in 1993-1994.' (p.57). Another development described by Freeman and Soete is the increased importance and flourishing of small and medium sized enterprises.

Both examples suggest that the advent of ICT affects the economy in various ways. If tends to reduce transaction and transportation costs and thereby fosters the market-mediated exchange of goods and services. Furthermore, the increased reliance on outsourcing enabled by ICT leads to internal reorganization, mainly resulting in the lay-off of management labour. Following Williamson (1985) we may interpret these lay-offs in terms of the market giving high-powered incentives and thus requiring little management to coordinate decisions. The internal reorganization of firms in turn leads to the advent of many small-sized enterprises (see also Gordon (1996)).

In the remainder of this section, we will, inspired by the before mentioned examples, use the model developed in this paper to predict the possible consequences of the advent of ICT for macroeconomic variables like growth, product variety and welfare. We also discuss whether private profitability and social desirability of outsourcing will (always) coincide. For this goal, we will look at the effects of a gradual decline in transaction costs for the desirability and profitability of outsourcing. Consistent with the previously discussed evidence, we will in the remainder assume that firms that rely on outsourcing need less management labour than firms that provide support activities internally.[16]

We introduce transaction or transportation costs by splitting the parameter δ into two parts (see equation (16)). One part reflects the *purely* technical productivity advantage of the monopolist (δ' which is larger than one). The other part

16 Note, however, as we discussed in the introduction, that the opposite case can also apply. The costs of monitoring the delivery of support activities, making contracts, and finding suppliers can be so high that the management costs increase when outsourcing occurs. In the analysis that follows, this possibility is left open, but not discussed explicitly.

reflects the fact that only a fraction $(1-t)$ of the produced amount of the support activity can effectively be used by the producer of the consumption good. (When conceiving t as a pure transportation cost of the iceberg type, one can imagine that a fraction t of the shipped production is 'lost' during transportation.) The parameter δ then equals $(1-t)\delta'$. Declining transaction or transportation costs associated with the advent of ICT are thus reflected in an increase in the parameter δ. Furthermore, changes in transaction costs are also reflected in the difference in the management requirement in the two regimes and in the presence of a fixed cost in the production technology of the monopolist with access to the superior technology. However, the three parameters reflect different factors. The parameter t comes closest to a real transportation cost for which location is one of the important considerations. Differences in management requirements L_m reflect organizational consequences of the decision to start outsourcing. The fixed cost requirement F should be conceived as the cost of acquiring the superior technology and acquiring relations with potential customers (e.g., Kelley (1997)).

To look at the effects of declining transaction costs in this model, we will rely on a graphical method. As we are mainly interested in the effect on profitability and social desirability of (i) changing transaction costs as captured by the change in δ, and (ii) changes in the management requirements of firms following a regime shift, we construct a $\delta - L_m^O/L_m^I$ diagram. In this diagram, we can construct three loci representing combinations of parameters for which $\pi_Y = 0$ (the PP locus), $N^I = N^O$ (the NN locus), and $U^O = U^I$ (the DD locus), respectively. These loci are derived from equations (21), (22), and (28); see Appendix B. They are depicted in Figures 1a–1c. The PP locus is vertical in the $\delta - L_m^O/L_m^I$ diagram. Irrespective of the management cost, there is exactly one value of δ for which the monopolist breaks even. At larger (smaller) values of δ, the monopolist makes profits (incures losses). This result is caused by the fact that changes in management costs resulting in changing firm sizes lead to equiproportionate (and opposite) changes in the number of firms. They consequently leave the macroeconomic demand for non-core activities unaffected, which ultimately is the factor determining the private profitability of outsourcing.

The NN locus is upward sloping. An increase in the relative management requirement (L_m^O/L_m^I) decreases, *ceteris paribus*, the relative number of firms (N^O/N^I). To offset this decrease, the superiority of the fixed cost technology has to increase (that is, δ has to increase). To the right (left) of the NN locus, N^O is larger (smaller) than N^I. With respect to the DD locus, we have to distinguish three cases. For high values of the love for variety relative to the intertemporal elasticity of substitution, the DD locus is upward-sloping (Figure 1c).[17] To ex-

17 In the specific case considered by Dixit and Stiglitz (i.e., $\sigma = \varepsilon/(\varepsilon - 1)$) we only need to consider one case. As stability of the equilibria with positive growth rates requires $\rho > \varepsilon$, it holds that $\varepsilon/(\varepsilon - 1) > \rho/(\rho - 1)$. We are thus in the situation where the taste for diversity is strong relative to the willingness to smooth the consumption profile. This situation is depicted in Figure 1c.

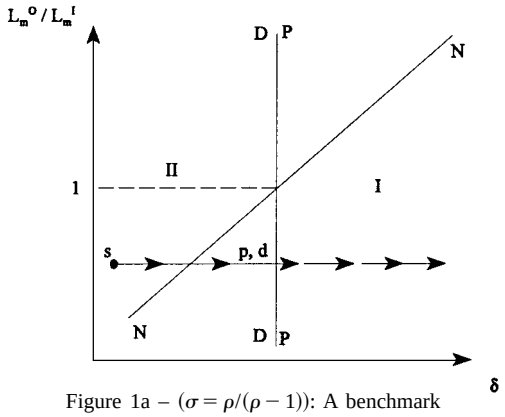

Figure 1a – $(\sigma = \rho/(\rho - 1))$: A benchmark

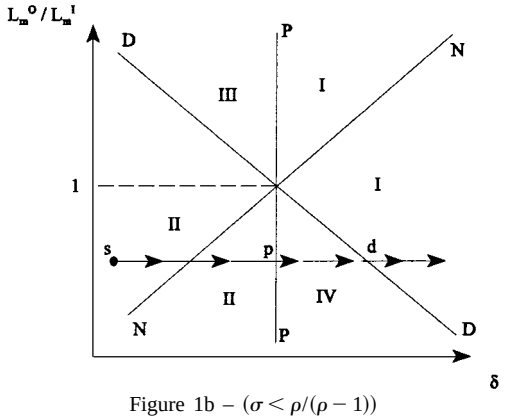

Figure 1b – $(\sigma < \rho/(\rho - 1))$

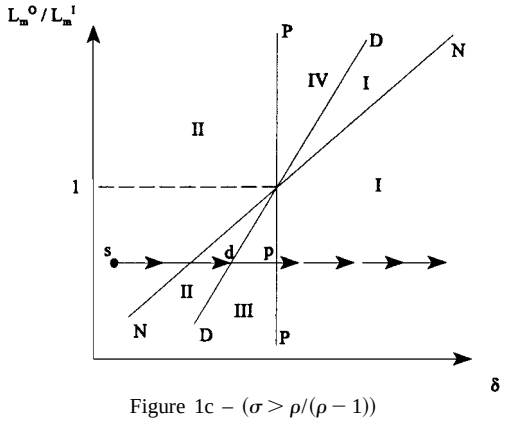

Figure 1c – $(\sigma > \rho/(\rho - 1))$

plain this, we look at a decline in δ. This decline in δ makes consumers, *ceteris paribus*, worse off in the regime with outsourcing. To compensate them in utility terms, N^O/N^I should increase relative to g^O/g^I. This follows from the fact that consumers have a strong love for variety relative to their willingness to substitute intertemporally (and thus to 'accept' a high growth rate). This change will come about, *ceteris paribus*, if the relative management costs (L_m^O/L_m^I) decrease (see section 2.2.3). Similarly, the DD locus is downward sloping when the love for variety is small relative to the intertemporal elasticity of substitution (Figure 1b). In the intermediate case where $\sigma = \rho/(\rho - 1)$ the DD locus is vertical (Figure 1a). This results from the fact that, *ceteris paribus*, a change in relative management cost leaves relative utility unaffected, as explained in section 3.1. To the right of the DD locus, at relatively high values of δ, outsourcing is the socially preferred mode of governance, while at low values of δ internal provision is preferred.

We are now able to consider whether private profitability and social desirability coincide. The results are described in proposition 3.

> *Proposition 3. Consider the case of continuously declining transaction costs. When* $\sigma = \rho/(\rho - 1)$ *and/or* $L_m^O = L_m^I$*, social and private desirability of outsourcing coincide. When* $L_m^O < (>) L_m^I$ *and* $\sigma < \rho/(\rho - 1)$*, outsourcing will occur too quickly* (*late*) *in the market from a social point of view. Conversely, when* $L_m^O < (>) L_m^I$ *and* $\sigma > \rho/(\rho - 1)$*, outsourcing will occur too late* (*quickly*) *in the market from a social point of view.*

This is further illustrated in Figures 1a-1c. In the case in which $L_m^O = L_m^I$ (the horizontal line in Figure 1a-1c on which $L_m^O/L_m^I = 1$), outsourcing leaves the growth rate unaffected. Outsourcing will hence be desirable if the equilibrium with outsourcing can sustain more firms. This will exactly be the case if outsourcing is a profitable strategy. In the case in which $\sigma = \rho/(\rho - 1)$, the partial effects on relative utility of a change in the relative management costs exactly cancel each other out (Figure 1a). Hence outsourcing will be socially desirable if it is privately profitable. The externalities resulting from changing growth and interest rates due to a shift from in-house provision to outsourcing exactly cancel each other out in this case. The market thus reflects the socially desirable trade-off to be made in deciding whether or not to engage in outsourcing. Clearly, this is only a knife-edge case of the model.

In general, social desirability and private profitability do not coincide. Let us consider the case where love for variety is relatively small and management costs are higher under in-house provision than with outsourcing (Figure 1b). It then holds that the growth rate is smaller under outsourcing than under internal provision of non-core activities. In the initial situation (point *s*) with relatively high transaction costs, firms provide their support activities internally, which is also the socially preferred mode of governance. As transaction costs decrease, the profitability of the monopolist with access to the superior technology increases until

it can just break even (point *p*). At that point, the monopolist will start producing support activities and outsourcing will take place. Due to the lower management costs in the regime with outsourcing, this shift in the mode of governance will be accompanied by a decrease in the growth rate and an increase in the number of firms. These effects are not taken into account by the monopolist, and from a social point of view there is excess entry. In region IV, outsourcing is socially undesirable. The market puts insufficient weight on the negative consequences for consumers' utility of the drop in the growth rate in making its decision to engage in outsourcing. As consumers have a relatively limited love for variety, the increase in product diversity is insufficient compensation for the drop in the growth rate. As the decline in transaction costs continues and product variety increases to a sufficiently large extent (in region I), outsourcing ultimately also becomes the socially preferred mode of governance (at point *d*).

Figure 1c describes the mirror image of Figure 1b. As transaction costs drop, a region is passed (region III) in which outsourcing does not take place though it would be socially desirable. At point *d*, consumers would prefer the switch to a regime of outsourcing and the accompanying increase in product variety at the expense of a somewhat lower growth rate (given their relatively strong love for variety). At this point, the demand for support activities is however not yet sufficient to make the use of the fixed cost technology profitable for the monopolist. To put it differently, in region IV, the monopolist is not sufficiently rewarded from a social point of view for its decision to start producing and selling non-core activities, and thereby, unintentionally, increasing product variety.

To conclude, (exogenously) declining transaction costs will ultimately (endogenously) result in outsourcing of support activities. This will affect firm size in two ways. There is a direct effect as goods initially produced internally are now bought on the market (the 'splintering' effect referred to in the introduction). The indirect effect results from internal reorganization of the firm. More specifically, we assumed that firms engaging in outsourcing require less management labour than firms engaging in self-provision. The consequences of these changes for firm size, number of firms and the attractiveness to outsource that are predicted by the model are in accordance with the developments discussed in the beginning of this section. Results peculiar to our specific model are the derived welfare consequences and the prediction that the lay-off of management labour (downsizing) will result in lower incentives to engage in R&D and a subsequent decline in the growth rate. This basically reflects the 'Schumpeterian' character of the model. There is much debate in the literature as to whether this result will hold in reality. Some economists (e.g., Eliasson (1992)) have argued that large firms are often unable to cope with the speed of change that is required in periods of technological and organizational turbulence. Pavitt (1986) on the other hand has argued that even very large firms are capable of learning and changing and that

they have great advantages to exploit all kinds of economies of scale, present in for example research and development.[18]

5 CONCLUSIONS

This paper has embedded arguments in the transaction cost literature as to why it may be optimal for firms to engage in outsourcing in a dynamic general equilibrium model. This model was subsequently deployed to study the macroeconomic consequences of outsourcing. More specifically, we established conditions under which outsourcing will be a privately profitable strategy. Next, we studied the macroeconomic consequences of outsourcing for economic growth, product variety, firm size, and welfare. It was shown that the private profitability and social desirability of outsourcing do not coincide in general. This is caused by the fact that firms do not take into account the consequences for product variety and market shares of their decision to engage in outsourcing.

A result derived from the model is that declining transaction costs are a crucial driving force behind outsourcing. We discussed the advent of information and communication technology. This development was shown to be potentially important in explaining the increase in outsourcing and downsizing of firms witnessed in recent years. The model predicts that these trends will be associated with an increase in product variety and a decrease in the macroeconomic growth rate. The first prediction seems to be confirmed by the available evidence. The second prediction relies crucially on the 'Schumpeterian' character of the model, implying that large market shares are conducive to R&D and economic growth. Finally, increased product market competition was shown to foster the incentive to engage in outsourcing. We are ultimately left with the conclusion that the decision to engage in outsourcing by private firms can have important macroeconomic consequences. This conclusion has so far been underestimated in both the theoretical and the empirical literature on outsourcing. Acknowledging this conclusion may, at least partly, enhance our understanding of the recent productivity slowdown, of deindustrialization, and the advent of many small firms supplying highly specialized inputs.

APPENDIX A

In this appendix, we will solve for the equilibrium growth rate, number of firms, and allocation of labour under alternative modes of governance ($j = I, O$) and under the assumption of symmetry. In the symmetric steady state, it holds by

18 Some other studies in favour of this line of argument mentioned in Freeman and Soete (1994) are Simonetti (1993) and Lovio (1994).

definition that:

$$g^j \equiv \frac{\dot{h}^j}{h^j} = \frac{\dot{c}^j}{c^j} = \frac{\dot{C}^j}{C^j}. \tag{A.1}$$

In addition, using the first-order conditions for firm behaviour ((8) and (9)), we can derive (note that $w \equiv 1$):

$$\frac{\dot{p}_h^j}{p_h^j} = -g^j = \frac{\dot{p}_c^j}{p_c^j} = \frac{\dot{P}_C^j}{P_C^j}. \tag{A.2}$$

For the regime with internal provision, we can thus write the no-arbitrage condition as:

$$r^I + g^I = \xi(1+a)L_c^I + \xi L_r^I \;\Leftrightarrow\; L_c^I = \frac{r^I}{\xi(1+a)}. \tag{A.3}$$

Substituting equation (5) and (8) into the zero profit condition (12), we get:

$$\frac{\varepsilon}{\varepsilon - 1} = 1 + \frac{L_r^I + L_m^I}{(1+a)L_c^I} \;\Leftrightarrow\; (1+a)L_c^I = (\varepsilon - 1)\left(\frac{g^I}{\xi} + L_m^I\right). \tag{A.4}$$

Combining (A.3) and (A.4), we derive:

$$r^I = (\varepsilon - 1)g^I + \xi(\varepsilon - 1)L_m^I. \tag{A.5}$$

Using (A.1) and (A.2), we can write the Ramsey rule (equation (2)) as:

$$\rho g^j = r^j + g^j - \theta \;\Leftrightarrow\; r^j = (\rho - 1)g^j + \theta. \tag{A.6}$$

Confronting the planned growth rate (A.5) with the Ramsey rule (A.6), we solve for the equilibrium interest rate and the growth rate:

$$r^I = \frac{\varepsilon - 1}{\rho - \varepsilon}[\xi(\rho - 1)L_m^I - \theta] \text{ and } g^I = \frac{\xi(\varepsilon - 1)}{\rho - \varepsilon}\left[L_m^I - \frac{\theta}{\xi(\varepsilon - 1)}\right], \tag{A.7}$$

where stability of the equilibrium with a positive growth rate requires $(\rho - 1) > (\varepsilon - 1) > \theta/\xi L_m$. Substituting the solution for the interest rate into (A.3) yields the equilibrium number of production workers per firm in the consumption

goods sector:

$$L_c^I = \frac{(\varepsilon - 1)\left[\xi(\rho - 1)L_m^I - \theta\right]}{(\rho - \varepsilon)\xi(1 + a)}. \tag{A.8}$$

Finally, substituting the solutions for L_c and $L_r(= g/\xi)$ into the labour market constraint (13), and using (5) and (11), we can solve for the equilibrium number of firms:

$$N^I = \frac{L\xi(\rho - \varepsilon)}{[\xi(\rho - 1)L_m^I - \theta]\varepsilon}. \tag{A.9}$$

The solution procedure for the growth and interest rates and the equilibrium number of firms under the regime with outsourcing is similar to the procedure for the regime with internal provision, and follows using equations (8)–(10) and (16)–(18). Using equations (A.1) and (A.2), we can write the no-arbitrage condition (10) as:

$$r^O + g^O = \xi(1 + ap_Y)L_c^O + \xi L_r^O \;\Leftrightarrow\; L_c^O = \frac{r^O}{\xi(1 + ap_Y)}. \tag{A.10}$$

Substituting equations (5) and (8) into the zero-profit condition (17), we get:

$$\frac{\varepsilon}{\varepsilon - 1} = 1 + \frac{L_r^O + L_m^O}{(1 + ap_Y)L_c^O} \;\Leftrightarrow\; (1 + ap_Y)L_c^O = (\varepsilon - 1)\left(\frac{g^O}{\xi} + L_m^O\right). \tag{A.11}$$

Combining (A.10) and (A.11), we derive:

$$r^O = (\varepsilon - 1)g^O + \xi(\varepsilon - 1)L_m^O. \tag{A.12}$$

Confronting the planned growth rate (A.12) with the Ramsey rule (A.6), we solve for the equilibrium interest and growth rates:

$$r^O = \frac{\varepsilon - 1}{\rho - \varepsilon}\left[\xi\,(\rho - 1)L_m^O - \theta\right] \text{ and}$$

$$g^O = \frac{\xi(\varepsilon - 1)}{\rho - \varepsilon}\left[L_m^O - \frac{\theta}{\xi(\varepsilon - 1)}\right], \tag{A.13}$$

where stability of the equilibrium with a positive growth rate requires the parameter restriction $(\rho-1)>(\varepsilon-1)>\theta/\xi L_m$. We can now derive the number of production workers and the firm size, using (A.10), $L_r = g/\xi$, and (A.13), as:

$$L_c^O = \frac{(\varepsilon-1)\left[\xi(\rho-1)L_m^O-\theta\right]}{\xi(\rho-\varepsilon)\,(1+ap_Y)},$$

$$L_c^O + L_r^O + L_m^O = \frac{\left[\xi(\rho-1)L_m^O-\theta\right](\varepsilon+ap_Y)}{\xi(\rho-\varepsilon)\,(1+ap_Y)}. \tag{A.14}$$

Using (5), (16), (18), and (A.14), we can solve for the number of firms:

$$N^O = \frac{(L-F)\,\delta\xi(\rho-\varepsilon)\,(1+ap_Y)}{\left[a(\varepsilon-1+\delta p_Y)+\delta\varepsilon\right]\left[\xi(\rho-1)L_m^O-\theta\right]}. \tag{A.15}$$

We can now determine the optimal price to be set by the monopolist providing support activities. Substituting the solutions for N and L_c into the profit function for the monopolist, we get:

$$\begin{aligned}\pi_Y &= Yp_Y - wL_Y = N^O a L_c^O\left(\frac{\delta p_Y - w}{\delta}\right) - wF \\ &= \frac{a(L-F)\,(\varepsilon-1)\,(\delta p_Y - w)}{a(\varepsilon-1+\delta p_Y)+\varepsilon\delta} - wF\,.\end{aligned} \tag{A.16}$$

From this expression, it is easily derived that $\partial\pi_Y/\partial p_Y > 0$. Thus the monopolist will set as high a price as possible (that is, the monopolist will engage in limit pricing: $p_Y = w \equiv 1$).

APPENDIX B

In this appendix, we will derive mathematically the equations underlying Figures 1a–1c. Using equation (21) (with equality), we derive that the number of firms is equal if

$$L_m^O = \frac{1}{\xi(\rho-1)}\left[(\xi(\rho-1)L_m^I-\theta)\left[\frac{(L-F)\,(1+a)\,\delta\varepsilon}{L[a(\varepsilon-1+\delta)+\varepsilon\delta]}\right]+\theta\right]. \tag{NN-locus}$$

Using equation (22), it follows that profits for the monopolist equal zero at:

$$\delta = \delta^* \equiv \frac{aL(\varepsilon - 1)}{aL(\varepsilon - 1) - F\varepsilon(1 + a)}. \qquad \text{(PP-locus)}$$

For larger (smaller) values of δ, the use of the superior technology is (un-)profitable.

Similarly, we derive from equation (28), that social indifference occurs at:

$$L_m^O = \frac{1}{\xi(\rho - 1)} \left[(\xi(\rho - 1)L_m^I - \theta) \left[\frac{(L - F)\,(1 + a)\delta\varepsilon}{L[a(\varepsilon - 1 + \delta) + \delta\varepsilon]} \right]^{\frac{\sigma(\rho-1)}{\sigma(\rho-1)-\rho}} + \theta \right]. \qquad \text{(DD-locus)}$$

Taking the derivative of this expression with respect to δ, it follows that the DD locus is upward-(downward-) sloping if $\sigma > (<)\rho/(\rho - 1)$, and vertical at $\sigma = \rho/(\rho - 1)$.

Now several points with respect to the relative position of the three loci need to be mentioned. First, the three loci will always intersect at the point where $\delta = \delta^*$ and $L_m^O = L_m^I$. Secondly, the DD locus will be vertical and coincide with the PP locus at $\sigma = \rho/(\rho - 1)$. Thirdly, the NN locus and the DD locus will coincide when $\rho = 0$. Since stability with positive growth rates requires ρ to be larger than 1, this coincidence will not occur. Finally, when $\sigma > \rho/(\rho - 1)$ and the DD locus is thus upward sloping, its slope is larger than the slope of the NN locus (since $\sigma(\rho - 1)/[\sigma(\rho - 1) - \rho] > 1$).

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